Translation into English

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Encased length-measurement device

The innovation relates to an encased length-measurement device, comprising a transparent ruler, which is accommodated within a tubular protective housing and has an incremental measurement graduation, and comprising an optoelectronic sensing unit which is shiftable along said ruler by a sensor, arranged outside the housing, via a sword or the like passed through a longitudinal slot of the housing. The optoelectronic sensing unit comprises a sensing plate, which is provided with reading fields in the form of reading gratings or the like, and photoelectric receivers assigned to the reading fields. One illuminating unit each illuminates the assigned photoelectric receiver through the reading grating or the like and the measurement graduation of the ruler.

Length measurement devices of this type are used, inter alia, on machine tools. Analog, generally sinusoidal measurement signals with a wavelength corresponding to the ruler graduation are generated at the photoelectric receivers during sensing of the ruler by the sensing plate and are passed on for further processing. Designs are preferred wherein four reading gratings with assigned receivers are provided and the reading gratings are shifted with respect to each other by any number of entire increments plus a quarter of the graduation, such that signals with a mutual phase shift appear during sensing. By coupling the signals in pairs that have a mutual shift of 180°, starting from the receivers, two sine signals are obtained with a 90° shift between them, which signals can be passed on for further evaluation. The shifting direction can be discriminated by knowing which signal leads the other. The signals themselves can be evaluated in different ways. According to one possible embodiment, the signals are converted to digital counting signals and applied to counting circuits, which in turn control display or control units, in which case, for example, the measured distance covered starting from a given or selected reference point appears. There are also multiplier circuits by which the ruler is electronically graduated. For additional graduation, there are also interpolation calculators, in most cases employed together with counting circuits. These interpolation calculators calculate interpolation values from the signals according to stored interpolation tables and combine these values with the counting signals to form display values or control values.

Even if a number of correction methods are known for compensating inaccuracies of the ruler and distortions of the ensuing analog signals, it is an aim worth striving for that the sensing signals obtained at the reading gratings be as uniform as possible with respect to each other in terms of signal shape and signal level. In addition to the gratings serving to generate the aforementioned analog measuring signals, use is often made also of additional reading fields to generate reference signals at reference marks of the ruler, and also further reading fields are employed which are directed only to the ruler and generate a signal corresponding to the average illuminance, according to which signal the amplification of the analog signals is then controlled so as to compensate any changes in the sensing signals caused by aging of the illuminating unit and receivers or by soiling of the ruler and of the gratings.

In a known length measurement unit of the above-mentioned type, the ruler element is mounted approximately in the middle of the reinforced ceiling of the tubular protective housing such that its one edge points downwards. The sensing unit carries a printed circuit board comprising photoelectric receivers on one side of the ruler and a further printed circuit board comprising light-emitting diodes assigned to said receivers on the other side of the ruler. The sensing plate may be either rigidly connected to the sensing unit or may itself be guided along the ruler element according to another variant. In this construction, a relative shift of at least the illuminating unit and the photoelectric receivers transverse to the ruler is possible. In order to achieve faultless sensing and signals that can be faultlessly evaluated, there is a need to use a ruler having a relatively wide graduation and correspondingly wide sensing gratings. To achieve an approximately uniform illumination of the photoelectric receivers by the light-emitting diodes, these light-emitting diodes have to be mounted at a specific minimum distance from the ruler. Nevertheless, there will be signal distortions in practice, which are due, among other things, to the fact that some light-emitting diodes squint, i. e. emit a light bundle which is at an angle to the main axis, and that the light-emitting diodes also illuminate the adjacent reading fields and photoelectric receivers. This scattered light leads to considerable signal distortions. In the described arrangement, the large ruler and the correspondingly wide sensing plate as well as the observance of the necessary distances of the light-emitting diodes from the ruler result in a relatively large required space and, thus, in a large clear opening of the tubular protective housing. It is necessary to pass the supply lines for the light-emitting diodes to the inside of the housing via the sword, and after assembly has been performed, a subsequent adjustment of the light-emitting diodes with respect to their position or replacement of individual light-emitting diodes is hardly possible or possible only at considerable cost. This results in a relatively large protective housing requiring a correspondingly large space. When evaluating the precision of measurement, the potential heating of the ruler by the lighting system, in particular in case of prolonged standstill, also has to be taken into account.

It is known per se in similar measurement systems to provide a common illuminating unit for all reading fields and to illuminate the reading fields by this illuminating unit via optics, e. g. a condenser. In practice, a circular light spot is generated, in most cases, via the optics. The reading gratings and/or reading fields and the photoelectric receivers then have to be arranged within this light spot, which results in a ruler having a correspondingly wide graduation. Accordingly, it is not possible here to arrange at least the most important reading fields in a single row. A reading field for a reference mark also has to be arranged within the aforementioned light spot. Thus, a correspondingly large protective housing results already from the wide ruler. Another known design has similar disadvantages, wherein the projection optics adjoining a light source illuminates a corresponding field of the ruler, with the reading fields provided therein, via a light cable. Projection optics and a light guide cable, too, are expensive, bulky components. In this case, the problem of heat dissipation is also not solved in a satisfactory manner. Illumination requires the use of lamps which are bulky as compared to the light-emitting diodes and sensitive to aging. When changing lamps, cumbersome adjustment work has to be carried out.

It is the task of the innovation to provide a length measurement unit of the aforementioned type, which enables a small design of the protective housing and of the ruler, while allowing high precision of measurement and faultless generation of signals, and which is easy to adjust and maintain.

The task thus set is accomplished, in principle, in that the illuminating units preferably provided as light-emitting diodes are accommodated outside the protective housing, in the sensor or sword, and only illuminate the associated reading fields and photoelectric receivers via light-guiding openings of the sword or the like.

In this design, a small construction of the protective housing is possible because, first of all, the illuminating units and their secondary units need no longer be accommodated in the protective housing itself. The reading fields are uniformly illuminated by the light-emitting diodes from a sufficient distance, said uniform illumination resulting from both said distance and the orientation of the light in the light-guiding openings, thus excluding any influence on the photoelectric receivers by scattered light from light-emitting diodes assigned to adjacent receivers. Thus, an essential prerequisite for generating correct sensing signals is fulfilled and it becomes possible to provide relatively small reading fields and a correspondingly narrow area for the measurement graduation on the ruler. Such narrow design is also possible because at least the reading fields serving to generate the normal measurement signals can be arranged in a row. Only reading fields for reference marks will be arranged with an offset. The undesired thermal

load of the ruler is eliminated. Due to the directing effect of the light-guiding openings, uniform illumination is possible even in the case of squinting of the light-emitting diodes. The arrangement and direction of the light bundles used for illumination are precisely predetermined and can, therefore, be precisely adapted to the arrangement of the reading fields and of the photoelectric receivers without requiring subsequent adjustment work.

The performance of maintenance work is facilitated if the light-emitting diodes, according to a further embodiment, are accommodated on a support in an arrangement corresponding to the reading fields in the sensor, which is then provided as an receiving box, at the inlet openings of bores of the sword directed to the reading fields of the sensing plate or the like, such that they can be accessed from the outside.

When using light-emitting diodes, the length of the light-guiding bores will be chosen several times greater than their diameter, so as to achieve the desired directing effect. A good light yield will be achieved, if said light-guiding bores have a smooth reflecting surface. In special cases, it is even possible to use folded bores as light bores and to mount reflectors for light deflection in the area of the fold. If a high light yield is not thought to be of great importance, use can also be made of blackened bores which will then only transmit directed light.

According to a further embodiment, the flat ruler element is attached in the protective housing that is to be mounted with the slot pointing downwards, said ruler being located such that its flat surface carrying the measurement graduation faces the slot, and the sensing plate is provided on the side of the ruler element carrying the measurement graduation, whereas the photoelectric receivers are attached to the rear surface of the ruler element. In this case, the width of the clear opening of the protective housing substantially depends on the required width of the ruler which is mounted to a side wall such that it protrudes towards the interior. Only mounts for the receivers have to be passed, in addition to the ruler, or in the case of a corresponding design, a guiding device for guiding the sensing plate along the ruler element has to be mounted. In this embodiment, the sensing plate is guided along the ruler and is adjustable relative to the remaining sensing unit to a predetermined extent, so that, if possible, an exact parallel shift of the sensing plate is effected with respect to the ruler.

As photoelectric receivers, photo elements or photodiodes are preferably provided, because these receivers do not need an energy supply of their own and merely have to be provided with port connections. In the receivers serving to generate the analog measurement signals, the circuit connection, for example a paired anti-parallel connection, can be provided in the region of the element and can just guide the connecting terminals of the circuits formed by the photo elements or photodiodes into the sensor. If importance is attached to a small constructional size

of the sensor as well, the evaluation and amplification circuits can be mounted separately from the sensor in an evaluation or intermediate unit. In this case, it will then only be required to establish port connections for the circuits and power supply connections for the light-emitting diodes.

The assembly and adjustment of the measurement device is substantially facilitated if, according to a further embodiment, the protective housing consists of two halves that can be assembled along a longitudinal seam. One of said halves carries the ruler element, comprises a guide for the sensing unit and is mountable on its own, whereas the other one can be attached to the first one as an end cap.

Further details and advantages of the innovative subject matter are evident from the following description of the drawing.

The innovative subject matter is illustrated, by way of example, in the drawing, wherein:

Fig. 1 shows a graphical representation of the length measurement device;
Fig. 2 shows a sectional view taken along the line II-II of Fig. 1, and
Fig. 3 shows a partial view of the sensor, sword and sensing unit for a protective housing indicated in a sectional view.

The length measurement device provided herein comprises a tubular protective housing, which consists of two halves 2, 3 that can be assembled along a longitudinal seam 1. Half 2 of the protective housing forms a unit with assembly blocks 4 and can be fixed to a machine with the help of mounting screws inserted in corresponding introduction openings 5 of the blocks, said openings 5 allowing adjustment. Corresponding blocks 6 serve to mount a sensor 7 on a part that is adjustable relative to the first machine part.

The rear end of the assembly blocks protrudes somewhat over the rear surface of half 2 of the housing so that there is no need for excessively high planarity requirements for the machine part to which the protective housing 2, 3 is to be mounted.

Half 2 of the housing which is mountable with the help of the blocks 4 substantially comprises the rear wall of the protective housing 2, 3. A ruler element 9 made of glass is clamped at one edge into a longitudinal groove 8 (Fig. 2) using an elastic sealing profile 10. The ruler element 9 carries a measurement graduation at its planar side pointing downwards. Beneath the groove 8 there is provided a further guiding groove 11 which may be used, if necessary, as a guide for a

sensing unit, which will then engage said groove 11 with a guiding rib 12 on a sword 13. The sensing unit is connected to the sensor 7 via the sword 13.

The sensor 7 forms an receiving box, which is accessible through a bottom-surface cover plate 14 and from which a connecting cable 15 is guided out towards an evaluating unit 16. A printed circuit board 18 is mounted in the cavity 17 of the box 7, said printed circuit board 18 having light-emitting diodes 19 mounted thereon. Each of said light-emitting diodes 19 is assigned one light-guiding bore 20 in the sword 13. The light-emitting diodes 19 are supplied with power via the cable 15. The light-guiding bores 20 are directed to reading fields of a sensing plate 21. In the exemplary embodiment, said sensing plate 21 is guided by flat sliding strips (not shown) at the left and right edges to the left and right of the measurement graduation on the bottom surface of the ruler element 9 and, in addition, by a side plate 22 on the free side of the ruler element 9 and is held in guiding engagement with the ruler element 9 by a spring 23, which starts at the sword and engages a ball 25 provided at the bottom surface of the plate 21 by a socket 24, such that the sensing plate 21 follows the ruler. The sensing plate 21 could also be guided along the inside of the housing part 2 by a guiding element that would then adjoin on the left-hand side in Fig. 2.

In the exemplary embodiment, the sensing plate 21 is assumed to comprise five reading fields arranged in a row and a sixth, laterally staggered reading field. Of the five reading fields arranged in a row, four carry reading gratings with a ruling that corresponds to the ruler graduation, but they are offset relative to each other by any number of entire graduation lines plus a quarter of the ruler graduation, so that during sensing of the ruler at photoelectric receivers, in particular photo elements or photodiodes 26, which are arranged at the rear surface of the ruler in a manner assigned to the reading fields, analog signals appear with a respective offset of 90° corresponding to the modulated illumination, most of said signals being sinusoidal and having, for example, the phase positions of 0°, 90°, 180° and 270°. By combining these signals in pairs by anti-parallel switching, two sine signals are obtained with an offset of 90° between them, which are subjected to further processing.

The fifth reading field located in said row, which is illuminated by a further light-emitting diode 19 and may be provided, for example, in the middle, serves to generate a reference signal that yields information about the average illumination intensity and according to which an amplification regulation can be effected. The sixth reading field is offset from said row and serves to read one or more reference marks in a trace of the ruler 9 that is offset with respect to the measurement graduation. The photoelectric receivers 26 are located on a conductor plate 27 provided as a carrier and are connected to the sensing unit 7 along the sword 13 via a slim conductor plate 28 which is soldered to the conductor plate 27 at right angles and is provided as

a bridge. The conductor plate 28 is connected to the sensing unit 7 via the cable 15. Circuit connections of the receivers 26 can also be established directly in the conductor plates 27 and 28. The conductor plates 27, 28 enable a slim design and precise mounting of the receivers 26. The evaluating unit 16 may either serve the purpose of complete signal processing or just that of partial signal processing. It is also possible to accommodate preliminary stages of the evaluating unit, such as signal-shaper stages, in the sensor box 7. The evaluating unit 16 is connected to a display or control unit or to a final stage of the evaluating unit, respectively, via a further cable 29.

During assembly, the ruler element 9 can be mounted to the part 2 and the part 2 can be mounted to the machine using the blocks 4. Before closing the lid 3, the entire sensing unit is also installed and adjusted, if necessary. The halves 2, 3 of the protective housing carry inserted sealing lips 30, which cooperate with the sword 13 and prevent dirt and humidity from penetrating into the cavity of the housing. The ends of said sealing lips 30 may be located within the blocks 4 and be closed there by silicone rubber parts. The cap 3 is put on after final assembly of the sensing unit, after which an edge 31 of the part 2 is flanged, thus producing a form-fit connection. The connecting seam 1 is completely secured by inserting a seal 32 or by gluing, respectively.